CLAIMS

1. A method of histological assessment of nuclear pleomorphism by identifying image regions potentially corresponding to cell nuclei in histological image data, characterised in that the method also includes thresholding the image data to render it binary, determining perimeters and areas of identified image regions, calculating image region shape factors from the perimeters and areas and assessing pleomorphism from the shape factors' statistical parameters.

2. A method according to Claim 1 characterised in that the shape factors' statistical parameters comprise at least one of their mean, weighted mean, median, mode, maximum and minimum.

3. A method according to Claim 1 characterised in that the step of thresholding the imaged data is Otsu thresholding.

4. A method according to Claim 1 characterised in that the step of assessing pleomorphism determines pleomorphism as being relatively low, moderate or high according to whether the mean or median of the shape factors is relatively low, moderate or high respectively.

5. A method according to Claim 4 characterised in that a shape factor S for an image region potentially corresponding to a cell nucleus is given by $S = \frac{kP^2}{A}$, where k is a constant, P is image region perimeter and A is image region area, and a mean shape factor S_m for a set of image regions potentially corresponding to cell nuclei is thresholded as $S_m \leq 30k$ (low), $30k < S_m \leq 35k$ (moderate) and $S_m > 35k$ (high) corresponding to pleomorphism being relatively low, moderate or high respectively.

6. A method according to Claim 1 characterised in that the step of thresholding the image data to render it binary is preceded by transforming colour image data into greyscale image data with improved image definition compared to an individual red green or blue plane in colour image data, and the step of thresholding the image data is carried out upon the greyscale image data.

7. A method according to Claim 6 characterised in that the step of transforming colour image data into greyscale image data is carried out by Principal Component Analysis (PCA) in which the greyscale image data is a first principal component.

8. A method according to Claim 7 characterised in that the step of transforming colour image data into greyscale image data is carried out by decomposing colour image data into a set of sub-images each of which overlaps half of each of its neighbours, and by implementing PCA for each sub-image, and the method also includes removing from each sub-image regions at sub-image edges potentially corresponding to cell nuclei.

9. A method according to Claim 1 characterised in that the step of identifying image regions potentially corresponding to cell nuclei in histological image data includes filtering the image data to overwrite regions which are not of interest using a filtering process which does not appreciably affect image region perimeter.

10. A method according to Claim 9 characterised in that the step of overwriting regions which are not of interest includes setting relatively small image regions to a background pixel value and setting hole pixels in relatively larger image regions to a non-hole image region pixel value.

11. A method according to Claim 1 characterised in that the step of identifying image regions potentially corresponding to cell nuclei in histological image data includes dividing the image data into overlapping sub-images, applying PCA to each sub-image to provide a respective greyscale sub-image and removing from the greyscale sub-images:

a) image regions touching or intersecting sub-image boundaries,

b) unsuitably small image regions, and

c) holes in relatively large image regions, and

reassembling the sub-images into a binary image.

12. Apparatus for histological assessment of nuclear pleomorphism by identifying image regions potentially corresponding to cell nuclei in histological image data, characterised in that the apparatus incorporates a computer programmed to

threshold the image data to render it binary, determine perimeters and areas of identified image regions, calculate image region shape factors from the perimeters and areas and assess pleomorphism from the shape factors' statistical parameters.

13. Apparatus according to Claim 12 characterised in that the shape factors' statistical parameters comprise at least one of their mean, weighted mean, median, mode, maximum and minimum.

14. Apparatus according to Claim 12 characterised in that the computer is programmed to threshold the image data using Otsu thresholding.

15. Apparatus according to Claim 12 characterised in that the computer is programmed to determine pleomorphism as being relatively low, moderate or high according to whether the mean or median of the shape factors is relatively low, moderate or high respectively.

16. Apparatus according to Claim 15 characterised in that the computer is programmed to determine a shape factor S for an image region potentially corresponding to a cell nucleus is given by $S = \frac{kP^2}{A}$, where k is a constant, P is image region perimeter and A is image region area, and the computer is also programmed to determine a mean shape factor S_m for a set of image regions potentially corresponding to cell nuclei, to threshold the mean shape factor as $S_m \leq 30k$ (low), $30k < S_m \leq 35k$ (moderate) and $S_m > 35k$ (high) and to indicate pleomorphism being relatively low, moderate or high respectively.

17. Apparatus according to Claim 12 characterised in that prior to thresholding the image data to render it binary, the computer is programmed to transform colour image data into greyscale image data with improved image definition compared to an individual red green or blue plane in colour image data, and the computer is also programmed to carry out thresholding of the image data using the greyscale image data.

18. Apparatus according to Claim 17 characterised in that the computer is programmed to transform colour image data into greyscale image data using PCA in which the greyscale image data is a first principal component.

19. Apparatus according to Claim 18 characterised in that the computer is programmed to:

a) divide the image data into overlapping sub-images,

b) apply PCA to each sub-image to provide a respective greyscale sub-image,

c) remove from the greyscale sub-images:

i) image regions touching or intersecting sub-image boundaries,

ii) unsuitably small image regions, and

iii) holes in relatively large image regions, and

d) reassemble the sub-images into a binary image.

20. Apparatus according to Claim 12 characterised in that the computer is programmed to set relatively small image regions to a background pixel value and to set hole pixels in relatively larger image regions to a non-hole image region pixel value.

21. Computer software for use in histological assessment of nuclear pleomorphism and having instructions for controlling a computer to identify image regions potentially corresponding to cell nuclei in histological image data, characterised in that the software also has instructions for controlling a computer to threshold the image data to render it binary, determine perimeters and areas of identified image regions, calculating image region shape factors from the perimeters and areas and assess pleomorphism from the shape factors' statistical parameters.

22. Computer software according to Claim 21 characterised in that the shape factors' statistical parameters comprise at least one of their mean, weighted mean, median, mode, maximum and minimum.

23. Computer software according to Claim 21 characterised in that it has instructions for controlling a computer to threshold the imaged data using Otsu thresholding.

24. Computer software according to Claim 21 characterised in that it has instructions for controlling a computer to determine pleomorphism as being relatively low, moderate or high according to whether the mean or median of the shape factors is relatively low, moderate or high respectively.

25. Computer software according to Claim 24 characterised in that it has instructions for controlling a computer to:

a) determine a shape factor S for an image region potentially corresponding to a cell nucleus given by $S = \frac{kP^2}{A}$, where k is a constant, P is image region perimeter and A is image region area,

b) threshold a mean shape factor S_m for a set of image regions potentially corresponding to cell nuclei as $S_m \leq 30k$ (low), $30k < S_m \leq 35k$ (moderate) and $S_m > 35k$ (high), and

c) to indicate pleomorphism being relatively low, moderate or high respectively.

26. Computer software according to Claim 21 characterised in that it has instructions for controlling a computer so that before thresholding the image data to render it binary such computer will transform colour image data into greyscale image data with improved image definition compared to an individual red green or blue plane in colour image data, and subsequently such computer will implement thresholding of the image data using the greyscale image data.

27. Computer software according to Claim 26 characterised in that it has instructions for controlling a computer to transform colour image data into greyscale image data by PCA in which the greyscale image data is a first principal component.

28. Computer software according to Claim 27 characterised in that it has instructions for controlling a computer to:

a) transform colour image data into greyscale image data by decomposing colour image data into a set of sub-images each of which overlaps half of each of its neighbours,

b) implement PCA for each sub-image,

c) remove from each sub-image:

i) image regions touching or intersecting sub-image boundaries,

ii) unsuitably small image regions, and

iii) holes in relatively large image regions, and

d) reassembling the sub-images into a binary image.

29. Computer software according to Claim 21 characterised in that it includes instructions for setting relatively small image regions to a background pixel value and for setting hole pixels in relatively larger image regions to a non-hole image region pixel value.